Proceedings of the SEDAR7 Red Snapper Assessment Workshops

The Assessment Workshop portion of the red snapper SEDAR actually was spread over two week-long sessions; the first in August, the second in December. The volume of new and past work, the desire to develop an “ultra-historical” data base, and problems with the first choice for a lead assessment model (ASAP) made it impossible to complete an assessment in the time period that had been allotted to previous SEDARs. Indeed, even the second workshop session ended with what was largely a set of instructions to the Miami assessment staff to guide the final model runs, with final assessment results to be circulated to the group later by email.

There are separate sections to this report for each of the sessions. The report roughly follows the developments at the meetings chronologically. However, some topics came up repeatedly, or were discussed in fragments between evaluations of analytical results. For these, comments from the several times a topic was discussed have been brought together here. Additional comments offered by AW participants after the second session ended (beyond those meant to edit or clarify the session reports) are collected in a third section. The fourth and final section collects the research recommendations made over the course of the meetings.

The discussions at the AW sessions tended to be qualitative, and strategic in nature. Technical details are generally to be found in the supporting reports (AW-# series), in the Data Workshop report, and in the supporting documents from the Data Workshop (DW-# series). There were about 90 technical documents, by and large consisting of previously unpublished work, submitted to the DW and AW. Because of the volume of new material, we have opted here for a ‘layered’ report, simply summarizing key points and subsequent discussion, with citations to the primary submissions. Reviewers are invited to ‘drill down’ through the collected papers to consider any topic for which they want more technical detail.

August Session

The first portion of the SEDAR Assessment Workshop (AW) for red snapper was held at the SEFSC Miami facility Aug 16-20, 2004. The meeting began by reviewing issues from the April Data Workshop (DW). Twenty new papers were submitted, most of them either making recommendations on points left undecided at the DW, or presenting results of additional analyses recommended at the DW. Preliminary assessment model runs using ASAP were conducted, directed at examining properties of individual factors prior to establishing a ‘base run’ assessment. An overview of a spatially separate assessment model under development was provided. Other models discussed included McAllister’s Gaming Model, and Walters’ VPA investigation. Both of these models included exploration of ‘ultra-historic’ information – landings and effort estimates derived from the years prior to the current data collection programs for fisheries statistics. It was hoped that this consideration of the full history of exploitation could provide additional insight into some of the problematic areas in interpreting past assessments. The meeting began with brief presentations on the new papers, with each presentation followed by open discussion of any topics inspired by the paper. The order here follows the order of presentation at the workshop.

Summary of Contributed Papers

AW-17 reported on an investigation of discrepancies in gear assignments of TX landings between past assessments and the current landings data files. A portion of the landings once attributed to the shrimp industry had been reclassified as longline (LL) landings in the commercial data files in the years since the CPUE index based on shrimper-landed snapper was first developed. Discussion revealed that there may well have been an expansion of the LL landings around that time, but no record supporting the reclassification of any particular amount of the catch to LL was ever found. The recommendation was that Texas data from the 1980-84 period be treated as unclassified as to gear, and the 1980-1984 period should be removed from the CPUE index derived from snapper landings by the shrimp fishery. Subsequent discussion touched on possible inclusion of landings from outside the US (believed by SEFSC scientists to have been adjusted in accord with all available evidence several years back for those years incorporated in the past assessments); the allocation of the 2003 catch between commercial handline (HL) and LL (currently based on logbook proportions);

the conversion factor between gutted and whole weight (currently 1.11 is used); and whether catches from outside the US are considered to come from a different stock (currently treated as coming from another stock.). Discussion later in the week reported on an AW recommendation to compare age composition in the purported shrimp trawler landings with trawl survey composition; it did appear there was an overlap. The allocation of catches between HL and LL came up at several times later in the meeting. The group recommendation was to investigate impacts of any possible misreporting by matching portions of the reported HL landings to LL size or age frequencies.

AW-3 reported on the calibration between 'old' and 'new' procedures for estimating charter boat catch in MRFSS. Questions arose about how Texas data fit into this issue. Texas has its own program, separate from MRFSS. The Texas system provides charterboat catch estimates, but these do not enter the ratios used to adjust MRFSS, and Texas catches are not adjusted using the MRFSS procedure. Uncertainties around the (estimated) adjustment ratios are not propagated forward into the estimates of uncertainty for MRFSS charterboat catches.

AW-2 updated the estimates of allometric conversion factors. Contrary to what was expected, significant differences were not found between east and west. There were also no significant differences from the factors used in the Goodyear assessments. The recommendation was to retain the size conversions used in the previous assessments.

AW-1 presented new growth results. Size at age has been clearly influenced by minimum size regulations, and the approach in this paper attempts to correct for that effect analytically. No east / west differences were evident in growth curves developed from data from any of the fisheries (commercial LL, HL; Recreational), so use of one Gulfwide curve was recommended. The parameter K was estimated to be somewhat higher than the value estimated in previous assessments (0.22 vs 0.16). This change appeared to be a consequence of the large increase in data available in recent years and changes in the minimum size, rather than a change in growth pattern over time.

AW-5 addressed fecundity and maturity estimation. This topic encompasses some of the largest biological differences from past assessments, and there are some real differences that result from choice of analytical method. Fecundity and maturity could be considered as direct functions of length, or as direct functions of age. Currently available modeling procedures ultimately require age-based functions, which means that if a direct function of length is assumed, an unbiased growth curve is a necessity. Or, a direct dependence on age could be assumed, bypassing the length to age conversion. The data base for reproductive biology was expanded considerably over the last few years. Results from two separate data sets were presented to the DW. The two sets analyzed separately led to somewhat different reproductive patterns, quite probably dominated by sampling differences. The DW recommended that simple combination of the two sets for a single analysis would be the best procedure. This has now been done. Analysis of the combined data found no east / west differences in either batch fecundity or fecundity*maturity, which was a bit of a surprise. However, the most important differences with the reproductive biology from past assessments (which assumed direct dependence on length) appear to be related to the new assumptions about growth. With the new curve, smaller fish are estimated to be more productive than in the previous stock assessment. However, a direct reproductive potential vs age function is now available also, so the AW has a choice. It was pointed out during discussion that separate age dependent and length dependent components might exist, and that relative strengths of the two possible components might differ among species. As this appeared to be a topic of some importance, without clear evidence within the data to indicate which method to favor, the AW felt that sensitivity work might be necessary. Discussion also mentioned the lack of information at present about frequency of spawning.

AW-16 considered use of U.S. Census data to lengthen the time series for the recreational fishery. A (log transformed) GLM related recreational catch to human population size, state, type of fishing, and year class strength (SEAMAP trawl survey), with interactions. Resulting parameters were used to predict catches prior to 1981.

AW-18 reviewed Goodyear's "probabilistic aging" method. The probabilistic procedure is known not to be mathematically rigorous (i.e. there is no mathematical basis to expect convergence as the number of iterations are increased), and modern assessment models do not require age composition vectors to match every catch. However, age data for the earlier years (1980s) are so sparse that incorporating probabilistic age estimates up front might have an advantage over leaving estimation of missing age compositions to an internal fitting in the assessment model. The analysis presented in AW-18 ran the Goodyear procedure for 3 iterations, and compared the results to similarly estimated age frequencies used in the previous assessment (Schirripa and Legault 1999) via bar graphs of percent age composition .Two stock structures were considered. The effect of the new (AW-1) growth curve appeared evident, particularly in the age 1 estimates.

AW-19 summarized the observed age composition data from otolith samples, and assembled age composition as matrices for 6 fisheries: commercial handline east (1991-2003), commercial handline west (1992-2003, less 1996-1997), commercial longline east (1991-2002), commercial longline west (1993, and 1998-2002), recreational handline east (1991-2003), and recreational handline west (1991-2003, less 1996-1997). It was noted that there were differences between the observed age composition and the probabilistic age composition.

At this point in the meeting, Clay Porch led a discussion of the Goodyear probabilistic aging method and the ASAP model. The discussion that followed covered a wide range of strategic issues for assessment models. Foremost was a debate over the virtue of stepwise incorporation and evaluation of changes from the 1999 assessment vs wholesale incorporation of new data, new estimation techniques, and modeling advances; with evaluation of differences to follow. The AW participants seemed to fall into two camps on this issue. However, as the ASAP model used in the previous assessment was known to require a number of isolated changes of 'hardwired' features to accommodate new information, a more stepwise approach was ultimately favored. A second important issue considered was the potential for misidentifying changes in abundance as changes in selectivity over time in age-structured models. Solutions offered included considering a VPA analysis as a check, and constraining changes in selectivity during model fitting. However, this was a contentious area, expected to require some time in evaluating model performance.

AW-20 covered the analysis recommended by the DW to develop age composition estimates for the shrimp fleet bycatch. The analysis showed considerable interannual variation in the age composition vector, a variation that was largely not present in the years available to assessments in the late 1990s. Some differences were noted in the amount of data used in AW-20 and in the data files held by LGL Consultants. These differences were found to be due to observations on trawls experimenting with or conducting certification testing on uncertified BRDs. As these BRDs were not in general use in the fishery, and in the case of certification testing, may have involved trawling selectively in areas of high snapper concentration, these trawls should not be considered representative of the overall fishery.

AW-15 presented an estimate for M at age 1 based on analysis of SEAMAP trawl survey data, using a method largely following a classical regression of Z vs effort. (This paper also covered the methods and data used in extracting separate CPUE indexes for age 0 and age 1 from the SEAMAP data.) AW-7 also considered estimation of M from the trawl survey data, based on an MLE programmed in AD Model Builder. It turned out that estimation was possible only by combining Fall-to-Summer and Summer-to-Fall estimates of Z in a single analysis, per AW-15. Without considering both seasons, there was insufficient contrast in the shrimp effort data to permit estimation. Later in the week, the AW group recommended using the 0.6 value derived in AW-15 as the point estimate of M at age 1. However, there may be as much of a message in the large confidence interval from AW-15 as in the point estimate itself.

AW-14 also considered juvenile M, in the sense of generating prior pdf's. This approach was recommended more for subsequent assessments rather for use on the time scale available for the current assessment. During discussion, the allometric strategy proposed by Lorenzen was also introduced.

Papers AW-8 and AW-12 addressed possible density dependence in juvenile M. AW-8 provided a formal structure to incorporate the timing of density dependent effects in a Beverton-Holt context, and the effects of different timings on a set of equilibrium population statistics. AW-12 presented yield curves based a particular set of assumptions with and without post-recruitment density dependence. (AW-12 also addressed the issue of linking F's from separate fisheries in MSY calculations.) Discussion of potential impacts of post-recruit density dependence occurred occasionally throughout the week. Those who had experimented with models incorporating "ultra-historic" data noted that it appeared difficult if not impossible to derive a realistic exploitation history without invoking additional density dependence. However, the group as a whole noted that there appeared to be no route available to estimate density dependence, or even decide upon its structure, based on existing data. Most all agreed that at the likely current levels of abundance, density dependent effects would not be immediately important in predicting population trends over the near future. However, the role, timing and strength of any density dependent effects could be very important over the longer term, particular regarding optimal allocation strategies.

There were some additional papers not covered by oral presentations during the paper presentation sessions. AW-4 and AW-9 presented updated indexes of abundance for the recreational and commercial handline fisheries, respectively, based on recommendations of the DW. There was also a short update paper on relative length frequency methods (AW-6a). The results from these papers were used in later discussions of indexes in the assessment models. Paper AW-13 was a commentary on the DW results, and many of its points came up in discussions throughout the week. Papers AW-6 and AW-11 covered modeling issues, and were addressed in the portion of the workshop looking at modeling results, so consideration of these papers appears in the next section. An additional 'paper' was available as a powerpoint presentation (.ppt format); this material was also covered during the discussion of modeling results.

Summary of Initial Modeling Results

The modeling efforts during the workshop began by establishing a 'continuity case' – a case matching as closely as possible the methods of the assessments of the 1990s, but including the data developed since that time. This analysis used the ASAP program, as did the most recent assessment. This continuity run was followed by considering a series of 'single step' changes, modifying items like fishery definitions, inclusion or exclusion of indexes, fixing and floating various parameters or constraints, considering alternative treatments that generate input data, etc., as suggested by the group. This process was aimed a getting an understanding the properties of the models and data prior to deciding on a 'base case' for the current assessment. Most of this effort was by necessity limited to the ASAP framework, but we were also able to consider results of a 'Gaming model' approach, and a classical, untuned VPA. Discussion of the data items in the submitted papers resulted in some new suggestions for analytical treatments, and the stepwise modeling changes proved time-consuming. By midweek, it was clear that one week would not be enough time to finish the assessment. The group continued investigation of modeling alternatives, but less driven toward reaching a full assessment or even a 'base case' by week's end, and more geared toward setting up what could be done prior to a second assessment workshop. The presentation of results here to capture only the more general discussions and results, in anticipation that a number of the runs presented during the week would be superseded by new material produced between the two workshops.

A recurrent, significant finding was that the ASAP model could not reliably fit both the steepness and virgin recruitment (R_{virgin})stock recruitment parameters if both were allowed to simultaneously estimated, at least if only the modern data were considered. The reason why was obvious: there has been a relatively large range in recruitment over the modern period, but an almost trivial range in spawning stock sizes. This was not a new discovery. The same problem has been discussed since at least the early 1990s. Although recruitment and spawning stock estimations are now available for many more years, it appears the spawning stock size has still not changed enough over that time for a reliable stock recruitment curve to be established. Many of the participants retained hope that inclusion of the "ultra-historic" data might provide some insight. There was hope the steepness and R_{virgin} might mainly impact the long term rebuilding issues – what the stock might be capable of producing near MSY. Shorter term advice might be less affected.

Another significant issue was the existence of differing directions of trends among several of the recent CPUE indexes. There was some measure of conflict noted between fishery dependent vs independent, and east vs west. There was general agreement that one should not simply include conflicting indexes in hopes the model fitting would sort things out. Results then would be driven by index weightings, and under most choices the result would be a flat 'average' that would be 'flat wrong.' There was a suggestion to contrast model runs containing only the upward trending indexes with runs containing only the downward trending indexes to bracket the uncertainty in the CPUE signals. This proposal seemed to obtain general support. There was an extended discussion of the extent of preference to be given to fishery independent information, with some participants preferring to use only fishery independent indexes when both independent and dependent indexes were available, and others recommending inclusion of both types. Consensus was less clear on this issue, but discussion ultimately trended more toward inclusion than exclusion. There was also some hope that the spatially structured model being developed could sort out differences that might be due to real east / west differences. However, it may be that the durations of the trends have not been sufficient to sort out true abundance changes in the most recent years from other possible causes.

Carl Walters expanded on results mentioned earlier in the meeting (no accompanying AW paper) using a classical VPA approach. Walters had been concerned that forward projecting age structured models may falsely interpret abundance changes as selectivity changes, especially with a dome-shaped selectivity pattern. His analysis found the expected peak in F at early ages, but also found traces of transient targeting of older fish. He felt that both factors present problems to models allowing fitting of selectivity. Waters also incorporated 'ultrahistoric' data into a stock reduction analysis, and suggested that it would very difficult to provide a plausible trajectory over the entire history of the fishery without adding additional dynamics like post-recruitment density dependence.

AW-6 laid out the structure for an assessment model (CATCHEM AD) that would allow consideration of multiple stocks, with movement among them. The model also has the potential to 'internalize' the probabilistic aging procedure in a more rigorous fashion and/or to use catch at age data. There was discussion about the ability to model any local depletions during development of the longline fishery, and for handling any changing vulnerabilities like those of Walters VPA by loosening selectivity constraints.

AW-11 summarized Murdoch McAllister's Gaming Model approach, with results from some trial runs, which by the second AW session, this model came to be referred to more often as the "SRA" (stock reduction analysis). Additional results were shown at the meeting, including incorporating density dependence at age 2. This model incorporated estimates of catch back to 1880. This model also had difficulty producing a trajectory going from an unfished state to current conditions with a single stock / recruitment function; adding post-recruitment compensation made the trajectories seem more plausible.

Approximately 3 dozen ASAP runs were completed during the course of the meeting. Most runs explored inclusion or exclusion of sets of CPUE indexes. These runs also explored the tension between R_{virgin} and Steepness by alternating fixing and fitting in the course of including indexes. Several of the runs looked at inclusion of data from the period prior to the current statistics programs. Four runs also incorporated the higher point estimates of juvenile M recommended during the meeting. . In general, inclusion or exclusion of any particular CPUE index did not change the results appreciably. Any model's evaluation of the status of the stock rested heavily on the treatment of steepness used.

The stock / recruitment problem remained a constant theme to the close of the meeting. Model estimates of recruitment (or inferences from CPUEs) suggest a relatively large range for recruitments since the 1970s, with stretches of several years with persistently higher or lower levels. Past discussions of evidence suggested recruitment may have been highest early in and just preceding the 'historical' period, but it now seems that ascribing any decline since then solely to changes in spawning stock size is incompatible with the lack of range of spawning stock during the historical period. Models using 'ultrahistoric' data suggested that it is difficult to get a time series of F that makes sense – smooth progressions with plausible assumptions about effort are either unresponsive, or too responsive, over some portion of the time series. The long age span of red snapper implies the adult population could be very slow in rebuilding age-sturcture and spawning biomass . Over the range of fishery information, the stock has seemed to become almost absent in the eastern portion of its historical range. In ASAP, fixing steepness in the range expected based on other species usually led to results suggesting a low (in some cases, an almost trivial) level of current F; in contrast, allowing steepness to be fit usually suggested very serious depletion. In sum, the results have not been entirely internally consistent. Adding additional dynamics might help, but there are multiple possibilities (e.g. post-recruitment density dependence, impacts of larger snapper on smaller snapper anywhere in the age range, M variation over time due changes in predator stock sizes, changing stock / recruitment parameters over time, grossly different selectivities over time, an outside source of new recruits). Most discussion at the meeting focused on compensation around age 2, but there is precious little evidence for or against that, or for or against any of the other possibilities at this time. We looked forward to December to learn if spatial subdivision and further development of the 'ultrahistoric' line of inquiry could provide any new insight into stock / recruitment.

December Session

The second portion of the SEDAR Assessment Workshop was held at the Wyndham Hotel in Miami, December 14-17, 2004. Discussion began with brief summaries of a new set of contributed papers, developed since the August meeting.

Summary of new contributions, and model development

Steve Turner began the discussion with an overview of progress since the August meeting. He introduced revisions to AW-18, which covered the modeling of the age composition used as input to ASAP. Catch at age matrixes were developed for multiple M's. He summarized the assessments that would be covered, emphasizing the advances in developing estimates of 'ultrahistoric' catches. He also cited two papers, AW-24 and AW-25, on ageing the closed season recreational catch and alternative juvenile trawl indexes, respectively.

Clay Porch covered reconstruction of a shrimp catch and effort time series (AW-23). The start of the offshore brown shrimp fishery relevant to snapper bycatch was taken to be 1948. The start of the Tortugas fishery was taken as 1950.

ASAP used catch estimates, whereas CATCHEM uses effort estimates as input for the prehistoric period. (For the shrimp fishery, the ultrahistoric period ends in 1960)

Clay Porch summarized the story of 'ultrahistoric' catch reconstruction for the commercial fishery (AW-22). Further investigation of the historical records since August resulted in several changes from the time series considered at the August meeting. There were scattered reports of local catches back to 1850, but the real beginning of the fishery was taken to be 1872, when 4 'smack' vessels began fishing inside 40 fm. The fishery grew rapidly, with first reports of local depletion appearing in 1885. Several sources were consulted to separate Campeche (off the Mexican Yucatan Peninsula) catches from catches from US waters. US statistics began recording water body in 1963. In the 1950s and 60s, there were major boat-building programs, leading to major increases in effort. There are no viable CPUEs available for the pre-historic period. Steve Turner answered questions about gutted vs whole weight. Gutting at sea apparently began in 1935, but the statistics reported were converted to whole weight. The statistics for 1955 stated that landings were expressed as whole weight; for 1956, the term 'landed weight' appeared instead. So, from 1956 on, weights reported were assumed to be gutted, with a 1.11 conversion factor.

Steve Turner summarized the runs to be presented:

VPA 1984 – forward
ASAP 1984 -- forward , 1962 – forward (ASAP 1872 – was not sucessful)
CATCHEM 1872 -- forward

Liz Brooks followed with a table of summary statistics for the runs made at that point (AW-33). A few possible transcription errors were noted by the group, to be checked later by Miami staff. This table became a 'living document' for additions and revisions made during and after the workshop. The current version is available as Table 2 of the overview report.

Liz Brooks presented results from two VPA papers (AW-28 and AW-29). Running VPAs was cited at the August session as a particularly important check on the validity of ASAP and CATCHEM given the domed-shaped selection pattern, which was deemed likely to enhance the danger of confounding selectivity changes and abundance changes. A number of projections forecasting future stock status were made. Technical details are available in the AW papers, with summary lines in Table 1 of the Overview Report.

Shannon Cass-Calay presented the ASAP results for 1984-forward (AW-30) and 1962-forward (AW-31). Two sets of 1984-forward runs were made: one set (the 'continuity' case) was most similar to the past assessments (with two indices of abundance used previously) and another set which used six indices. All the 1984-forward model had 6 fleets and , updated fecundity estimates. The parameter for (log) virgin stock size was estimated; steepness values (h) were fixed, with runs at h=0.81, 0.9, and 0.95. Fits to the catch data were generally good, except for bycatch, especially pre-1990. Gerry Scott commented that this run with updated data, modeled using logic very similar to previous assessments, gave results very similar to previous assessments.

Group discussion then centered on assumption used in projections. The projections presented used a scenario developed by economists, predicting declines in shrimping on the order of 40% over the next several years. Questions were raised about the review status of that report, and several participants expressed concern that they had not seen the source document. The advice ultimately given was to be sure to be clear about both what is assumed about shrimp effort trends, and what is assumed about survival from any F reduction in the shrimp fishery in any final presentations. No one advocated any single scenario for projections.

Shannon Cass-Calay presented results for the ASAP runs from 1962 forward, Gulfwide (AW 31). Mauricio Ortiz presented results of separate East and West ASAP analyses (again, for 1962 forward, AW 34). This effort proved difficult, with many prelimary runs required. There are no actual age data available pre-1984, and the model returned nonsensical results if none were input. To get a solution, age compositions averaged over 5 years from each fleet were calculated, and introduced into the analysis for the years lacking data. This allowed the model to reach a solution, but the model had an additional problem with catches of zero (some of the years were pre-longline, when catches of zero were correct for that fishery). Addressing this problem by substituting small positive numbers for catches of zero led to large differences in MSY depending on what small number was substituted. Although results were otherwise plausible, this 'instability' of the ASAP model was a serious concern (and later figured in the group's decisions to recommend the CATCHEM model). Carl Walters suggested the problems were related to the lack of information in changing, dome shaped vulnerabilities. Clay Porch disagreed, and felt that the problems were more likely related to the complex and *ad* *hoc* penalty structures hard-wired into the ASAP model, which were reasonable for the short time-series were possibly inappropriate for longer time-series of catch-effort data. (Further investigation was conducted in Miami after the meeting, and to date no fully satisfactory explanation for the instability has been found.)

Josh Sladek-Nowlis presented results of a bootstrap analysis of sensitivity to juvenile M requested at the August AW session (AW-32). ASAP was fitted with a front end that allowed recalculation of the full ASAP procedure with random draws from a distribution of juvenile M values approximating the uncertainty described in AW-15. Runs were made at three levels of steepness (h = 0.81, 0.9, and 0.95). Response to M variation was generally as expected. Benchmark responses were monotonic with M except for SS_{2004} / SS_{MSY} at the highest steepness. Qualitative descriptions of stock status remained similar throughout the range of M considered. The range of steepness considered varied the stock status results far more than the M range considered, and some interaction between steepness and juvenile M was evident.

Clay Porch presented results from the CATCHEM model for 1872 forward (AW 27). The model incorporates East and West geographic divisions (at the Mississippi River). The fishery was presumed to start from a virgin situation in 1872. Thirty ages are used, starting at age 1. There are three 4-month seasons as time steps. All spawning and recruitment is modeled to occur in the second season. A Beverton-Holt spawner / recruit structure is assumed. The parameter corresponding to steepness is a fitted parameter, with a prior; but all runs so far ended with steepness very near or at the upper bound allowed, ~0.97. The age-related fecundity description was taken as the primary, with a length-related function also run for sensitivity. M_1 was set at 0.6 per year; with 0.3 run made for sensitivity. The commercial HL fishery was started in 1872. The longline fishery started in 1980. The recreational fishery was assumed to start in 1946. The closed season commercial fishery (discards) was treated as a separate fishery for modeling purposes, beginning in 1991. Shrimp bycatch catches began in 1972, but shrimp effort data were incorporated back to 1960, and reconstructed effort estimates extended back to 1945. Indexes included handline (as Landings per unit effort), MRFSS, SEAMAP trawl at age 1, SEAMAP larval index, and the SEAMAP video index (Appendix 1. Table 5). Only observed age composition was used (Appendix 1. Table 8) . Commercial catches (presumed intended to be censuses) were assigned an arbitrarily low CV of 0.1. Weightings were all based on reported CVs for the data elements to which the model was fitted; in addition process variance was estimated for the relationship between the indices and abundance..

In general, the base CATCHEM model was able to fit the catch, effort, indexes, and composition data very well. Only the West larval index (with its increasing trend) failed to be fit. The F’s reported in the presentation results were actually catch rates, not mortality rates (some discards live). The productivity of the West was estimated to be about 3 times the productivity of the East. Current catch levels in the East did not appear to be sustainable. The sensitivities considered modified results in the directions expected, although the magnitude of the changes was somewhat less than observed in other model applications.

Carl Waters commented that the CATCHEM results looked very similar to his VPA results. Murdoch McAllister also noted the similarities to his SRA results.

Murdoch McAllister provided an update to his SRA (“gaming”) model (AW-26). He stressed that he felt the SRA model was appropriate for gaining insight, but not for making management predictions. The model did not fit catch at age directly, instead it uses average output from ASAP runs for selectivity and recruitment deviations. Basically, the model did not provide a plausible trajectory over the ultra-historical period unless a post-recruit density-dependent mortality mechanism was added to the model. Once density dependence was added, model results resembled the results from ASAP and CATCHEM presented at the second AW session.

The group discussion again visited density dependence discussion. The SRA approaches had difficulty fitting the pre-historical catch series without incorporating some post-recruitment density dependence. ASAP tended to underpredict the shrimp bycatch (which had high CVs in many or the earlier years of the time series), which McAllister suggested might be evidence of density dependence. Porch countered that a better fit to bycatch might simply mean that the trawl survey series were not fitted quite correctly. Consensus moved to starting the population modeling at age 1 (per CATCHEM). Information contained in age 0 catch-effort observations would be lost, but this might best deal with the problem of uncertainty about the timing of any density dependence. Discussion spread to the different modeling approaches in general, with participants citing their opinions on the pro’s and con’s of each approach. The similarity of the results between VPA and CATCHEM was noted as evidence that CATCHEM was not plagued by confusion between selectivity and mortality change. The lack of numerical instability in CATCHEM compared to ASAP was also reiterated. Finally, CATCHEM was endorsed by the group as the recommended model structure to apply for characterizing the status and likely future prospects of the Gulf red snapper resource.

Several possible alternative scenarios within CATCHEM were then discussed. Suggestions included:

1) revising the stock recruitment function to include a density dependent M component explicitly (deemed not doable in short term) as a longer-term research activity.
2) model a common larval pool (easy to do)
3) model the shorter time series
4) fix steepness at the central tendency of the prior (~0.8)
5) force the model to fit the shrimper landed CPUE index
6) consider a single index to eliminate the logbook index conflict (eventually decided against doing)

Most of the assessment staff returned to the lab to work on the alternative scenarios. The remaining AW participants discussed projections into the future and other issues. These topics are considered in a later section, as discussions and CATCHEM results presentations were interspersed over the remainder of the meeting. First, this report will summarize the CATCHEM results.

The CATCHEM run with the common larval pool was not run to completion. It was stopped once it was clear that results would be very similar to runs presented previously. Virgin recruitment in the east was raised slightly.

Fixing steepness at 0.81 fit the catch and index data about the same as the base case when compared by visual inspection. The ratio of virgin recruitment West:East dropped to 2:1 (was 3:1 in the base case).

Forcing the model to fit the shrimper CPUE was an attempt to mimic the logic used in the pre-1998 assessments, where recruitments in the 1960s and early 1970s were inferred to be much higher, and characteristic of near-virgin levels. This model predicted that an unrealistically large kill must have taken place in the recreational fishery in the period before recreational catch data were recorded. An alternative was suggested, setting R_0 to the $R_{1960\text{'s}}$ level. This alternative also required very large recreational catches in the 1970s (well above levels expected in the historical reconstruction) to fit all other aspects of the data.

The shorter time series request was accidentally mis-specified in coding changes, and was deferred until after the meeting.

Collected summary of topics discussed

Discussion by AW participants not involved in running assessment models at the meeting covered a wide range of topics. Many of the key topics tended to come up repeatedly but intermittently as the group alternated between awaiting and wading through model results. A Presentation of these comments and discussions chronologically would be hard to follow, so this report isolates the major topic and collects points of view expressed over the duration of the meeting. Topics highlighted here are MSY definition, steepness, geographic structure, release mortality, management tools, future shrimping patterns, past treatment of stock / recruitment, most recent recruitments, abundance vs selectivity, and habitat enhancement and density dependence

MSY definition. Although the MSY concept and the uncertainty properties for its estimation have been discussed critically for many years; recent assessment developments have actually led to an increased ambiguity in the definition of MSY. With more detailed models better characterizing selectivity in individual fisheries, new definitions conditional on observed or targeted selectivities have emerged. This situation was discussed at length in the snapper SEDAR meetings (see particularly DW-51), but no consensus was reached. Some argued for keeping MSY as a property of the stock by use of simplified and standardized selectivity vectors. Others preferred definitions incorporating realistic selectivity expectations, with the advantage of keeping MSY benchmarks more meaningful to real fisheries. The most difficult issue for red snapper is accounting for extreme selectivity differences among the different fisheries, especially how to incorporate the shrimp fishery in snapper MSY calculations. Several participants stressed that no choice is truly “policy neutral.” Recent previous assessments had used scenarios named ‘linked’ and ‘unlinked,’ with linked calculating MSY using proportional reductions set equal in all fisheries, and ‘unlinked’ setting the shrimp fishery to high, arbitrary reduction. The 'unlinked' terminology was also used to describe results of projections that varied the F's independently among fisheries, which became a source of confusion.

The CATCHEM-based assessments discusses stock status relative to 3 different selectivity structures, named pre-shrimp, post-shrimp, and linked. Pre-shrimp describes the case with F due to shrimp bycatch set to zero, with the name reflecting the rather late development of a significant shrimping mortality component in the history of the snapper fishery. Post-shrimp MSY benchmarks leave shrimping F at the status quo (average of 2001-2003), reflecting the possibility the 'reducing bycatch to the extent practical' has largely been reached. However, 'post-shrimp' also applies to future projections in which shrimp F may be manipulated separately from directed F's to anticipate future changes in shrimping effort or BRD technology. 'Linked' continues to refer to proportional changes in all partial F's, and is included largely for historical continuity.

It is very important to recognize that evaluation of stock status with respect to any MSY is very dependent on the choice of MSY definition used.

Steepness. The preliminary CATCHEM results were all consistent with steepness ~1. Steepness near 1 is still an unexpected result for many of the AW participants. There are several reasons why an assessment could produce a steepness near 1:

1) The assessment is correct; steepness really is very high
2) The historical catches were a great deal higher than recorded in the statistical reports and archives.
3) The portion of the results suggesting recruitments are near maximal today is an artifact of modeling very different types of information in different eras
4) There are important dynamics not modeled in the current assessment structure. The most likely possibilities include:
    a. Density dependent mortality in (post-recruit) juveniles
    b. Density dependent mortality in adults
    c. Delayed density dependence (adults vs juveniles)
    d. Changing M over time, not related to snapper density (reduced predators)
    e. Increasing carrying capacity over time for pre-recruits (regime change, artificial reefs)
    f. Increasing carrying capacity over time for adults (oil rigs)
    g. Stock extends geographically well beyond assumed range (Campeche connection)

Discussion by the AW included speculation on possible mechanisms for each (a few are listed parenthetically). Each AW participant had favorites, but the best advice at present is probably that <u>all</u> are speculative, and it would be a mistake to single out any possibility for further research or analytical focus, to the exclusion of any of the others. Remember also, that there is no need to invoke any of these mechanisms to fit the current data. The main reason for considering any of them is disbelief about the steepness result. It is certainly possible that the primary CATCHEM model could fit the data well, but be mechanistically incomplete. However, it seems inappropriate to simply force structures that include these potential dynamics into the current model at this time. It is unlikely that the current data could provide any realistic support for any of these postulated mechanisms. Improving our knowledge in all these areas should definitely be considered for future research.

Geographic structure. Perceived low mobility of juveniles and adults, possible geographic differences in vital rates, and especially, stable isotope evidence convinced the DW to recommend consideration of spatial substructure in this assessment. Interestingly, some of the follow-up analyses conducted after the DW did not support major rate differences between East and West. However, adding the geographic substructure has appeared to reduce the problem of conflicting CPUE indexes. The CATCHEM runs completed during the workshop did suggest plausible differences in the histories of East and West subdivisions of the population. CATCHEM could actually do a lot more with interchange rates in the adult phases, for which there was some evidence presented at the DW. However, exchange estimates available looked very cohort-specific, and estimates were available for very few year classes. The group decided it would be inappropriate to include rates for only that handful, with no acceptable way to predict the rest for this assessment, so exchange modeled was basically larval. This should be a project for the future, as data accumulate.

Release mortality. The DW report provided a thorough airing of what is known about release mortality, and recommended values to be used. However, the issue was brought up again at the second session of the AW. Some argued that the differences ascribed to recreational vs commercial release mortality are too large, because boats of both fleets are often seen in close proximity. Others argued that differences in practices, and differences in depth distributions for the two fleets taken in their entirety would dominate. Discussion ended without specific recommendations for values different from those recommended by the DW, but concern clearly remains that not enough is known about release mortality rates.

Management tools. Several of the constituents' representatives have asked for analyses to evaluate effectiveness of specific management tools (e.g. size limits, slot limits, bag limits, non-proportional F reductions, etc.), and understandably have expressed some frustration at repeated postponements of taking up these issues. Unfortunately, there is little value in running these types of analyses until we have completed the more general analyses about status of the stock. Because the time required to finish the status of stock modeling has extended so long, we have been unable to consider anything but the most basic management scenarios in time to be included in this report. Many of the requests for detailed management scenarios may have to be completed after the SEDAR RW.

Future shrimping patterns. The AW did not reach full consensus on future time series of shrimp F's to be considered in projections of future yields. All wanted to see a range of levels considered, such as is customary in isopleth diagrams of status metrics vs directed TAC vs shrimp F reduction. However, these diagrams contain no explicit time information. A scenario exists with a trajectory for shrimping effort, developed by economists. The group split somewhat on the potential use of that scenario, with some feeling it was a worthwhile to consider (but not as the only scenario), while others expressed concern that the scenario had not been reviewed at either the DW or AW.

Past treatments of stock / recruitment. As early as 1990, the scientific community was aware that the existing data would not support fitting a stock/recruitment function for red snapper. At a workshop held in Pascagoula in 1990, a stock / recruitment function was constructed for the purpose of forecasting stock sizes under hypothetical management scenarios. Three pieces of evidence were considered relevant to estimating recruitment prior to the earliest direct data available. First, The NMFS Fall Groundfish Survey (a predecessor of SEAMAP) extended back to 1972. The 1972 point was several-fold higher than any other point in the time series. (The raw data were consulted, and there were indeed many stations with elevated catches during the survey.) Second, a Landings Per Unit Effort index based on red snapper landed by shrimp trawlers had been constructed for the 1960s through the 1980s. (A the time, these were believed to have been trawl-caught, but limited to market size fished. Industry members later indicated a substantial portion of these fish may have been caught be hook and line during inactive periods on shrimping trips.) This index paralleled the Groundfish index very closely with a 1 or 2 year lag for years in common, and showed a level pre-1974 that was several times the 1980s level. The third piece of evidence was that red snapper total commercial landings dropped sharply in the early-mid 1970s. (There were no recreational data from that period.) The group concluded the recruitment must have been substantially higher from 1972 back at least through the 1960s than in the mid 1980's. Discussion centered around virgin recruitment being about a factor of 10x the recruitments of the mid 1980s. To pick a point for modeling, the 1970-74 shrimper CPUE index was divided by the shrimper CPUE index for 1984-88, and the result was 8.5. The group felt this was a conservative estimate of virgin recruitment, in that the long history of exploitation had probably reduced recruitment somewhat by 1970-74. After a few trials with simpler structure, a Beverton Holt S/R equation was developed by forcing the curve through 2 points: recruitment at 8.5x the mid-1980s level, spawning stock (as egg production) in equilibrium with that recruitment in the absence of fishing; and the mean of 1984-1988 recruitment (from Goodyear's assessment model), mean 1984-1988 spawning stock . The belief at the time was that increasing fishing pressure through the 1960s had reduced the spawning stock enough to compromise recruitment. Everyone recognized that the level of virgin recruitment was not certain, and thus the potential production at much reduced fishing levels was not certain, but unrecorded discussion suggested at least some participants would consider anything from 2x to 20x the recent recruitments as within the range of possibility.

This heuristic construction of a stock recruitment function was superseded in the late 1990s by analyses based on systematic alteration of the steepness parameter using the ASAP model. In that context, status inferences tended to be closely linked to steepness assumptions, and fairly large ranges in possible ABC were reported back to the Council. Results that predicted unexpectedly high standing stocks at MSY came under particular criticism, largely on energetic grounds. It now appears energetic considerations do not rule out many of the higher values (see DW-12), but with potential yields still predicted to be higher than ever believed to have occurred, the highest MSY outcomes remained suspect.

In the interim between the 1990s assessment and the present, some alteration to the data base regarding landings by gear in Texas occurred (see AW-17). No documentation for the changes was ever found, so the shrimping Landing per Unit effort index cannot now be considered reliable. The index remains reported here, but it did not play a role in fitting the assessment models.

Inclusion of the 'ultra-historical' data in the current assessment has now provided additional insight. Several attempts were made to 'force' a result simulating the 8.5x recruitment change between the late 1960s and mid-1980s using the CATCHEM model. The only outcomes that allowed recruitments at that level required unrealistically high recreational catches in the pre-MRFSS era. It was a bit surprising that the model did not support even temporarily high recruitments as consistent with all other data, but clearly, CATCHEM results at the AW did not support the idea that virginal recruitment was much higher than recruitments currently occurring. Although it might be conceivably possible to add new dynamics to CATCHEM that leads to a result more consistent with elevated recruitment in the past, the opinion of the AW was that a past, higher recruitment scenario should now be considered an unlikely scenario.

Most recent recruitments. Concern was expressed about declines in recruitment in the most recent 3-4 years evident in some model outputs. These results appeared most prominent in some of the VPA results, but were not a strong feature in others. All participants had some concern, and some participants expressed a lot of concern, but ultimately the group did not appear to consider this topic to be a central issue.

Abundance vs selectivity. The similarity of the CATCHEM and VPA results appeared sufficient to satisfy the group that seriously misleading outcomes due to confounding of abundance and selectivity changes, such as discussed at length in the first AW session, were sufficiently ruled out for the snapper assessment.

Density dependence and habitat enhancement. The possible importance of post-recruit density dependence has been a central topic at both sessions. An interesting, related issue raised by Carl Walters was that perhaps juvenile snapper survival may have been increased due to system changes induced by heavy trawling pressure. A subcommittee was formed to draft text covering these topics, and their contribution forms the remainder of this subsection. Notes made at the meeting suggest that there was less enthusiasm for the strength of evidence that trawling may have enhanced survival than implied here, but the AW group was certainly willing to air the viewpoint.

> At present, the red snapper assessment model recommended by the Assessment Workshop participants assumes that density dependent survival takes place prior to fishing impacts, as do most assessment model applications. However, the red snapper situation is complicated by the fact that fishing impacts occur at such young ages. Consequently, the common assumption is more tenuous here than elsewhere. At present adequate data are not available to resolve the period during which density-dependent survival takes place. From a policy perspective, perhaps the most significant implication of these unknowns is in our confidence of the effectiveness of bycatch reduction efforts, including bycatch reduction devices (BRDs). It is very unlikely that continued data collection of fishery independent and dependent information as currently being used in the assessments will resolve the uncertainty in the near future, due both to variability in the data and confounding of bycatch effects with other factors that may be causing recruitment changes (regime shifts, changes in stock size). The quickest and perhaps most economical way to determine the net impact of bycatch reduction measures would be to conduct a large-scale adaptive management experiment, involving closure of some areas to trawling and careful comparative monitoring of red snapper juvenile abundances in closed vs open areas.
>
> To the extent that existing data can provide insight, two lines of evidence suggest that current assumptions might be wrong, and that density-dependent mortality may take many of the juveniles "saved" through bycatch reduction measures:

1) long term population models (stock reduction analysis) indicate that historical fishing effects would have been minor if historical recruitments had been as high as would be expected from current bycatches;
2) the Seamap data is consistent with density-dependence in survival rate from age 0 to age 1 (Figure 1).

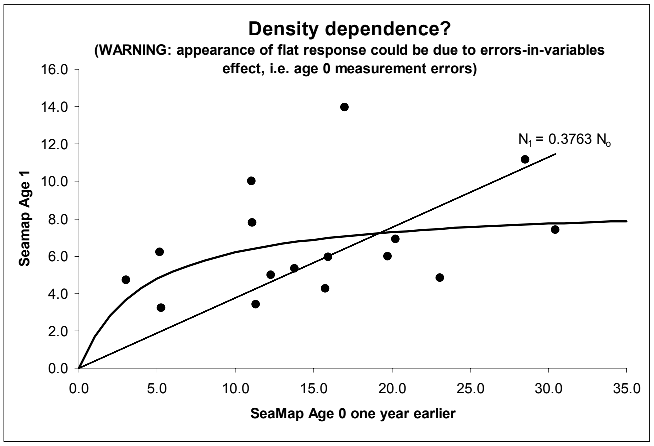
However, it is possible that historical recruitment rates were lower for some other reason (dome shaped recruitment, possible enhancing effects of shrimp trawling on snapper juvenile survival due to removal of predators, environmental regime changes), and the apparent density-dependence in juvenile survival could be an errors-in-variables effect (data show artificially high range of regression X values due to measurement errors in X).

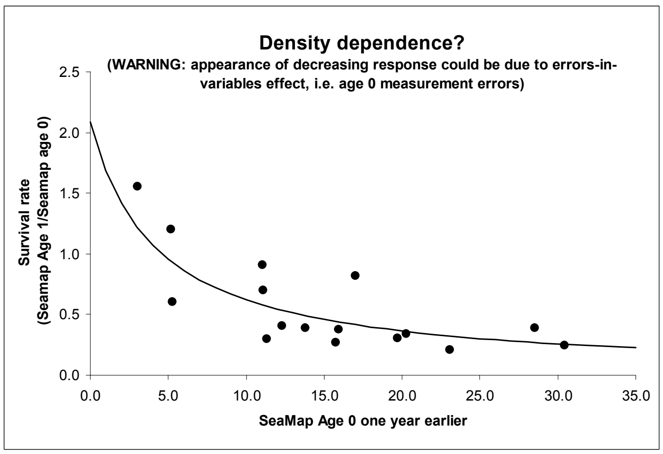
We should not be surprised to see continuing density-dependence in juvenile mortality rate over the ages intercepted by shrimp trawls. There are few published studies of timing of density-dependence in juvenile mortality (eg Myers and Cadigan 1993), but the evidence that is available indicates that density-dependent effects may occur until fish reach relatively large sizes (review in Rose et al. 2001). Models based on juvenile foraging behavior and associated predation risk predict continuing density-dependent effects until those ages where total M is quite low (Walters and Martell 2004). Observations of snapper behavior indicate, size-dependent spacing effects, with smaller fish being displaced to potentially less favorable sites when they encounter larger conspecifics. Such spacing effects are likely to result in density-dependent mortality due to predation risk during “forced” dispersal events (even if that predation risk is not cannibalism per se).

While density-dependent effects may prevent recruitment increases following implementation of policies aimed at bycatch reduction, recent data are consistent with an even more counter intuitive possibility: the habitat and fish community “disruption” effects of shrimp trawling may actually be resulting in improved juvenile survival of red snapper. There is a broad positive correlation between shrimp fishing effort and recruitment rates estimated using the CATCHEM long term model, and VPAs indicate a peak in recruitment during the early 1990s followed by reduced recruitments in the late 1990s following implementation of BRDs. However, this evidence is weak for two major reasons: (1) Most of the recruitment estimates from CATCHEM are modeled rather than observed, and could be highly sensitive to model assumptions. (2) Any suggestion of decline in recent recruitment are driven by three unusual years that do not correspond with the implementation of BRDs in 1998, including a spike in 1994 and 1995 and apparent dramatic drop in 2003. Nonetheless, it is a global expectation by shrimp fishers that trawling causes improved shrimp recruitment, most likely due to removal of competitor and predator fish species, and this expectation is supported by ecosystem models for one case situation (Great Barrier Reef lagoon area; Neil Gribble, Queensland DPI, pers. Comm.). Perhaps this same “cultivation” or enhancement effect has influenced the red snapper as well.

Whether because of density dependent mortality or reduced survival enhancement effects, there is risk that policies aimed at bycatch reduction have either negligible or the opposite effect from that intended. This means that even the direction of snapper response to bycatch and shrimp effort reduction is uncertain. It is unlikely that continued data collection of fishery independent and dependent information as currently being used in the assessments will resolve the uncertainty in the near future, due both to variability in the data and confounding of bycatch effects with other factors that may be causing recruitment changes (regime shifts, changes in stock size). An adaptive management experiment, as outlined above, would be the most effective way to gain insight into the strength of linkage between fishing impacts on young red snapper and the status of the red snapper population as a whole.

Figure 1. Evidence of density dependence in red snapper mortality rate from age 0 to age 1 is present in the Seamap data, when age 0 numbers are used to predict either age 1 numbers the next year (no density dependence would result in proportional response on average), or survival rate to age 1.





AW Participant Contributions after the Second Session

Murdoch McAllister was able to update his SRA results with using data revisions from the AW. He submitted a short document summarizing his methods and key findings, which has been added to the AW collection as AW-35. The description of results made at the AW held upon updating. The model could not fit a plausible trajectory for the 1872-forward period without invoking post-recruitment density dependence. Adding density dependence at either age 1 or age 2 did allow a plausible trajectory, and producing results similar to the ASAP and VPA results presented at the AW. With density dependence, shrimp bycatch reduction had little impact on future trajectories. Recovery by 2032 required a reduction in TAC, and failing to reduce TAC led to a collapse within the next 10 years under this model.

Research Recommendations

A subcommittee was formed at the second AW session to collect the research recommendations made over both sessions. They singled out several important items, and provided short write-ups on each on behalf of the AW group. (This list was developed to expand on several key items; other research recommendations brought up during the meetings remain worthy.)

The most important research needs are:

1) direct measurement of current fishing mortality rates,

2) experiments to determine the magnitude and timing of density dependent compensation in juveniles,
3) information on the effects on shrimp trawling on red snapper through community effects including nutrient cycling and changes in predation pressure,
4) continuation and expansion of the fishery-independent survey for adult red snapper,
5) more information on release mortality and discard rate by depth, season, and fishery,
6) additional alternatives for reducing bycatch such as closed areas etc.,
7) additional research such as simulation testing on the estimation properties of stock assessment methods and models,
8) distribution and mixing between the East an West.

Measurement of fishing mortality rates

A Gulf-wide mark-recapture program could provide a direct measure of current fishing mortality that would allow us to evaluate mortality estimates from the model, MSY, and risk in harvesting older fish through commercial longlining. Traditional tags such as spaghetti tags have a problem with tag shedding. Pit tags are sometimes missed in the recapture phase, and both types of tags cause disturbance to the fish during the tagging phase. A new type of tag that doesn't cause disturbance during tagging and that cannot be lost is a genetic tag, or an identification of the fish based on its DNA. A DNA sample is taken from a fish on the bottom using a special hook that bends, releasing the fish, and bringing up only a small piece of the flesh. The DNA sample is analyzed, and a catalog of individual DNA fingerprints is created. During the recapture phase, DNA samples are taken from harvested fish at fish houses or aboard commercial or recreational boats, and compared to the library of 'tagged' fish. With a large enough sample size of tagged and recaptured fish, then the fishing mortality rates can be calculated.

Density dependent compensation in juveniles

Past assessments assumed that the sole population control occurs at a life history stage before red snapper become vulnerable to shrimp trawling (at about 5 cm). Biological reproductive potential, some behavioral observations and evidence from stock reduction analysis suggest that compensatory mortality occurs during or after shrimp trawling. SEDAR7-AW-08 and SEDAR7-AW-12 make the case that the efficacy of bycatch reduction is significantly impacted if compensation occurs during or after the juvenile life stages. Experimentation with areas measure juvenile survival from the age-0 to age-1 year at different densities of juvenile abundance would provide the needed information.

Effects of shrimp trawling on red snapper

Possible enhancement effects of shrimp fishing may lead to uncertainty about efficacy of bycatch reduction policies. Direct assessment of juvenile survival responses to elimination of shrimp bycatch mortality can be achieved through the monitoring of several replicated pairs of experimental open and closed areas. The number of areas, the size of areas and the location of areas, monitoring methodology, variables to monitor and statistical design must all be determined. To test the hypothesis that red snapper production is actually enhanced by the release from predation that happens when bycatch removes a community that includes many species of predatory fishes, characterization data by observers aboard shrimp vessels on the individual species in the bycatch is needed. This type of data was formerly collected under the characterization program starting in 1992, but data collected since 1998 has been either specifically on red snapper or has been on BRD evaluations, which only collects data on 22 individual species of concern. Data on all species in the catch could be put into ecosystem models to evaluate the effects on red snapper of the removal of predators such as lizardfish, small flounders, Portunid crabs, sharks, and others.

Fishery-independent abundance index

Currently, NMFS's Pascagoula Laboratory conducts a long-line survey in the Northern Gulf of Mexico that could be expanded spatially to cover the red-snapper's range. The existing information should be used as pilot study to design a survey with adequate numbers of samples by season. This series would be more applicable i.e., fewer assumptions, than the larval survey that is currently used to index spawning biomass.

Release mortalities by sector, season, fish size, and depth

As regulations become more restrictive, more fish are released. For example the current assessments include an additional fishery – closed season discards. With the advent of biomass-based benchmarks, it is essential to account for the deaths of released fish. The SEDAR 7 Data Workshop Report examined the existing information on release mortality by sector and east vs. west Gulf concluded that commercial release mortality was 80% while recreational release mortality was 15% in the East and 40% in the West. The commercial estimate was based primarily on samples from Louisiana, which may not reflect the depth distribution of commercial fisheries in Texas or further east. The discrepancy between commercial and recreational release mortality and East and West release mortality that can not solely be explained by differences in depth need further exploration. Other difficulties are that many of the estimates were based on immediate sink or swim data, which may not be indicative of delayed mortality, that none of the estimates include increased natural mortality due to predation by dolphins or barracuda that eat fish before they can return to depth, and that most of the studies do not include differences in mortality of released fish based on size, season (either based on water temperature or closed vs. open seasons), or depth. Discard rate should also be related to recruitment indices one to two years previously, but there is not yet a time series of data built up to show this relationship.

Sampling for age composition of the catch.

Differences were observed between the observed age composition and the probabilistic age composition particularly for the commercial handline fishery. The intensive sampling otoliths from the fisheries which was initiated in the late 1990s should continue. A presentation by scientists from Louisiana State University on the age composition of red snapper discards from the directed red snapper handline fishery from late in 2001 through each 2003 indicated a younger age composition of open season discards than estimated in the probabilistic aging procedure. Such sampling should be continued and expanded to cover a larger fraction of the fishery.

Additional management measures to reduce bycatch

Recent onboard observations indicate that BRDs as actually used reduce bycatch of red snapper by only about 11%. Because fishermen tinker with their nets to reduce shrimp loss rather than to reduce bycatch, and because slight differences in BRD placement and fishing practices such as haulback procedures can have large effects on BRD efficacy, BRDs may not be able to reduce snapper bycatch as much as may be desired, and other alternatives such as closed areas, effort limitations, etc. may be desirable. More research is needed to explore these options and their potential for reducing bycatch in addition to BRDs.

Testing of the estimation procedures used in stock assessments

This assessment used a suite of methods – Virtual Population Analysis (backward), two statistical catch-at-age models (forward), and two stock reduction analysis (forward). A worthwhile exercise that would lend confidence to the assessment results is to simulate a test data set with known characteristics and to apply each of the models to that data set to see whether the methods can estimate the original parameters (N.R.C. 1997).

Mixing and dispersal

Due to differences in the effort, landings, stock structure and the potential for different stock dynamics, the recent stock assessment looked at the East and West Gulf separately. These models make some assumptions about mixing and migration of both adults and larvae. The Western Gulf appears to have higher landings and higher recruitment, and it is not know whether this stock acts as a source to provide larvae to the Eastern Gulf stock. More information on movements and dispersal of larvae based on the location of the spawning stock and physical oceanographic parameters would give insights into the metapopulation dynamics of red snapper and how the East and West runs should be linked. Similarly, the isotope research that suggests exchange among young (but recruited) fish should be continued.

Planning Workshops

The present assessment exercise can only identify the critical research needs and propose a general approach that may address the issue. We suggest two structured workshops to design and evaluate the feasibility of the programs. Simulation models should be constructed to ensure that the measured variables and analytical tools are capable of achieving the program objectives. The attendees of the workshop will be the relevant scientific experts as well as user group representatives.

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